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Title:
"Hot-fire Test Results of an Oxygen/RP-2 Multi-Element Oxidizer-Rich Staged-Combustion Integrated Test Article"

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Abstract:

As part of the Combustion Stability Tool Development project funded by the Air Force Space and Missile Systems Center, the NASA Marshall Space Flight Center was contracted to assemble and hot-fire test a multi-element integrated test article demonstrating combustion characteristics of an oxygen/hydrocarbon propellant oxidizer-rich staged-combustion engine thrust chamber. Such a test article simulates flow through the main injectors of oxygen/kerosene oxidizer-rich staged combustion engines such as the Russian RD-180 or NK-33 engines, or future U.S.-built engine systems such as the Aerojet-Rocketdyne AR-1 engine or the Hydrocarbon Boost program demonstration engine. For the thrust chamber assembly of the test article, several configurations of new main injectors, using relatively conventional gas-centered swirl coaxial injector elements, were designed and fabricated. The design and fabrication of these main injectors are described in a companion paper at this JANNAF meeting. New ablative combustion chambers were fabricated based on hardware previously used at NASA for testing at similar size and pressure. An existing oxygen/RP-1 oxidizer-rich subscale preburner injector from a previous NASA-funded program, along with existing and new inter-connecting hot gas duct hardware, were used to supply the oxidizer-rich combustion products to the oxidizer circuit of the main injector of the thrust chamber. Results from independent hot-fire tests of the preburner injector in a combustion chamber with a sonic throat are described in companion papers at this JANNAF conference. The resulting integrated test article – which includes the preburner, inter-connecting hot gas duct, main injector, and ablative combustion chamber – was assembled at Test Stand 116 at the East Test Area of the NASA Marshall Space Flight Center. The test article was well instrumented with static and dynamic pressure, temperature, and acceleration sensors to allow the collected data to be used for combustion analysis model development. Hot-fire testing was conducted with main combustion chamber pressures ranging from 1400 to 2100 psia, and main combustion chamber mixture ratios ranging from 2.4 to 2.9. Different levels of fuel film cooling injected from the injector face were examined ranging from none to about 12% of the total fuel flow. This paper presents the hot-fire test results of the integrated test article. Combustion performance, stability, thermal, and compatibility characteristics of both the preburner and the thrust chamber are described. Another companion paper at this JANNAF meeting includes additional and more detailed test data regarding the combustion dynamics and stability characteristics.